URANIUM ENRICHMENT

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND PRODUCTION

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

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URANIUM ENRICHMENT

THURSDAY, JULY 28, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION,
Washington, D.C.

The subcommittee met, pursuant to call, at 9 a.m., in room 2325, Rayburn House Office Building, Hon. Marilyn Lloyd (chairman of the subcommittee) presiding.

Mrs. LLOYD. The subcommittee will come to order.

Good morning, ladies and gentlemen. This hearing is the second step in a series of oversight activities that the subcommittee has undertaken to review the uranium enrichment program. This oversight began with the fiscal year 1984 authorization hearings, during which the subcommittee identified advanced gas centrifuge machine development as a target of opportunity for the funding enhancement in fiscal year 1984. I'm pleased to note that the Energy and Water Development Appropriations Conference Report contained an additional $11 million for this R&D work, which is the figure our subcommittee and full committee has recommended in H.R. 2587.

This hearing will consider the results of the congressional Budget Office draft report which was done at the request of myself and the former ranking Republican member of the subcommittee, Mr. Lujan. The report presents the total cost of various investment strategy options for the United States uranium enrichment enterprise.

The framework for this report is the question—Does the United States plan to seriously compete for foreign as well as domestic customers in the uranium enrichment market into the first quarter of the next century? There is no simple answer to the question because of the major uncertainties introduced by the large secondary market in uranium enrichment. The pricing of foreign competitors in excess production capacity which will probably persist into the 1990's.

This committee has a very unique function. It is the one committee in the House which has responsibility to look far into the future, to make tough decisions on where this country should be headed downstream. The question of choosing an optimum uranium enrichment strategy is precisely the kind of question that we on the Science and Technology Committee should be answering from a congressional perspective in the next few years.

This draft report addresses only the relative costs of various investment options. However, it is an important element in the over-

sight process and does provide us with an economic benchmark. With this kind of information, both the Congress and the Administration are in a better position to incorporate additional factors, such as the relative risks of the advanced technologies.

These advanced technologies include advanced gas centrifuge and the atomic vapor laser isotope separation process. We are also cognizant of the fact the DOE pricing formula requires considerable scrutiny since for roughly the next decade it will be a major factor in determining market prospects for enrichment services.

I intend to have a subcommittee hearing on this topic during the budget review process early in the next session and this may be an area where we could request additional work by our friends at CBO. I must say that I do appreciate this solid job that CBO has done on this study. The results are proving more timely. You are to be congratulated.

It appears to me that today's testimony will stimulate some very good questions and I am looking forward to a very informative morning.

I don't believe Mr. Walker is present this morning but, without objection, we will include his opening remarks in the record.

[The opening statement of Mr. Walker follows:]

OPENING STATEMENT BY THE
HONORABLE ROBERT S. WALKER

ERP SUBCOMMITTEE HEARING
THE CBO REPORT ON ENRICHED URANIUM

JULY 28, 1983

MADAM CHAIRMAN, I WELCOME THE OPPORTUNITY TO DISCUSS THE REPORT BY THE CONGRESSIONAL BUDGET OFFICE ON "SUPPLYING ENRICHED URANIUM THROUGH THE YEAR 2025." WHILE I REALIZE THAT OUR DISCUSSION TODAY WILL BE LIMTED TO THE CBO REPORT I BELIEVE THAT THE OVERALL TOPIC OF THE PROPER GOVERNMENT ROLE IN THE FUTURE IN URANIUM ENRICHMENT ACTIVITIES IS ONE WHICH THIS COMMITTEE MUST ADDRESS IN THE NEAR FUTURE.

IN EARLIER HEARINGS ON THE DEPARTMENT OF ENERGY 1984 BUDGET REQUEST WE EXAMINED THE FUNDING FOR THE NEW GAS CENTRIFUGE ENRICHMENT PLANT ALREADY UNDER CONSTRUCTION AT PORTSMOUTH, OHIO. HOWEVER, WE ARE INTERESTED IN THE POSSIBILITY THAT THE PORTSMOUTH FACILITY MAY BE A PROPER CANDIDATE FOR ADVANCED GAS CENTRIFUGES WHICH SHOULD BE DEVELOPED BY THE END OF THIS DECADE. WE ARE ALSO QUITE INTERESTED IN THE ATOMIC VAPOR LASER ISOTOPE SEPARATION (ALVIS) PROCESS. THESE OPTIONS ARE ALL INCLUDED IN THE CBO REPORT AND WILL BE DISCUSSED HERE TODAY.

I AM CONCERNED, HOWEVER, THAT THIS REPORT DOES NOT ADDRESS OUR WORLD AND DOMESTIC URANIUM MARKETS AND HOW DOES THE DOE PRICING POLICY RELATE TO ACTUAL COSTS AND OUR ABILITY TO COMPETE IN THE MARKETPLACE?

WE WILL ALSO HAVE TO LOOK WITH SOME CARE AT THE EFFECTS OF THE URANIUM SECONDARY MARKET AND HOW IT WILL IMPACT ON VARIOUS STRATEGIES WHICH DOE MIGHT ADOPT TO RECLAIM AMERICAN LEADERSHIP IN THE WORLD MARKET.

ALL OF THESE OPTIONS WILL HAVE TO BE EXAMINED IN CONSIDERABLE DETAIL BEFORE WE WILL BE ABLE TO RECOMMEND A COURSE FOR THIS NATION IN THE FUTURE.

I WOULD LIKE TO WELCOME OUR WITNESSES BEFORE THE COMMITTEE THIS MORNING, AND I LOOK FORWARD TO THEIR COMMENTS.

Mrs. LLOYD. Dr. Bodde, will you please proceed, and would you introduce your colleagues for the record.

STATEMENT OF DAVID L. BODDE, ASSISTANT DIRECTOR, NATURAL RESOURCES AND COMMERCE, CONGRESSIONAL BUDGET OFFICE, ACCOMPANIED BY JOHN THOMASIAN, PRINCIPAL ANALYST, ENERGY, NATURAL RESOURCES AND ENVIRONMENT, CONGRESSIONAL BUDGET OFFICE; AND MOLLIE QUASEBARTH, ANALYST, NATURAL RESOURCES AND COMMERCE, CONGRESSIONAL BUDGET OFFICE

Mr. BODDE. Yes, I would, Madam Chairman.

I'm very pleased to introduce Mollie Quasebarth and John Thomasian, both of whom were the key participants in the CBO study.

Mrs. LLOYD. I must say again they did a fine job.

Mr. BODDE. Indeed, they did. Thank you, ma'am.

We are pleased to appear before your committee this morning to discuss Federal investment options for supplying enriched uranium. The issue before the Congress is whether to continue using existing enrichment technology or to finance new processes, and if the latter, which new technology might prove to be the more cost-effective investment.

My remarks this morning will touch upon three points: the status of U.S. enrichment services in the context of the world market; options to lower the costs of the United States' enrichment

services and the economic consequences of these options; and the major uncertainties that surround the analysis.

My remarks are drawn from material in a detailed study CBO is now preparing for your committee.

The CBO's economic analysis indicates that advanced new processes could significantly lower both the cost of providing enrichment services and the price the customers pay for nuclear fuel. Of the candidate technologies that CBO has examined, the advanced gas centrifuge process, termed AGC, appears to be the least expensive from the viewpoints of both the Government and the utility consumer. But compared to the total cost of the enrichment enterprise over a 43-year operation period—the span of CBO's analysis—the differences among the leading technologies appear to be small.

These findings also must be viewed in light of two uncertainties. First, technical difficulties can arise in the development of any new process, and the effects of these difficulties cannot be anticipated in economic analysis. Second, the world market for this product has become highly competitive since the United States began to sell enriched uranium more than a decade ago, at times influenced by factors quite separate from price. Thus, the United States' ability to supply enrichment at low cost cannot guarantee that a customer will be found for the product.

Electric utilities need enriched uranium to fuel nuclear reactors to provide the Department of Energy with uranium feed and receive the enriched product in return. The amount of work required to enrich natural uranium sufficiently for use as reactor fuel is defined as the separative work unit, or SWU. A reactor requires roughly 80,000 to 120,000 SWU a year under the typical enrichment specifications. By law, the U.S. enrichment enterprise must recover its full investment and operating costs. This leads to a charge of roughly $140 per SWU, roughly 4 percent of the average delivery cost of nuclear-generated electricity. Enriched uranium fuels 144 gigawatts of installed nuclear capacity in the free world, of which about two-fifths is in the United States and about three-fifths is overseas.

The U.S. position as an international supplier of enriched uranium has diminished markedly. Between 1969 and 1979, the United States was the dominant free world supplier of enrichment, but now it supplies less than 35 percent of the market outside of the United States. Three related factors have influenced this drop—price, overcapacity, and a desire for energy independence by foreign producers.

First the price. Some foreign producers charge as little as $100 per SWU—$40 less than the U.S. rate. To some extent, the strength of the U.S. dollar against foreign currencies and other nations' support for their enrichment plants account for this disparity. This price difference has motivated concern that the United States invest in technologically advanced facilities capable of producing SWU at significantly lower costs.

But such investment must consider global overcapacity in SWU production, a second reality influencing the world market. A large global SWU inventory is building—estimated at roughly 60 million SWU, or a three-year world supply at the current rate of consumption. World enrichment capacity today is about 42 million SWU

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and may expand. Of this, foreign enrichment plants can supply almost 15 million SWU a year, including Soviet exports of roughly 3 million SWU. The United States is now capable of supplying about 27.3 million SWU per year. Net U.S. capacity is not expected to increase through the end of the century, but by the late 1990's annual foreign capacity may rise by about 6 million SWU, leading to a global capacity of about 48 million SWU.

Because actual growth in nuclear generation has fallen far short of earlier expectations, world demand is unlikely to exhaust this production capacity before the end of the century. Actual yearly world demand for enrichment is about 20 million SWU. Annual production, however, is probably around 25 million SWU, because contract provisions require many customers to take the SWU's for which they have no current need. World demand is not likely to press even on current capacity limits until late in the century, reaching roughly 51 million SWU per year by the year 2000. Thus, the large inventory of enriched uranium is likely to remain a major market force, depressing world prices and fostering strong competition for sales.

Non-price considerations are also important. Many nations entered the enrichment market to gain greater control over their energy supplies and to promote domestic industry. Already committed to the large fixed costs inherent in uranium enrichment, foreign producers may be reluctant to lose sales even to low-priced U.S. enrichment.

Taken together, excess production capacity, a large inventory of already-enriched uranium, and the national interests of foreign suppliers introduce considerable uncertainty into the outcome of any investment program. Foreign producers might themselves invest in low-cost enrichment technology or, alternatively, simply cut their price to the level necessary to maintain market share. Thus, a clear potential exists for a decline in SWU price, perhaps even to levels that would make difficult full cost recovery of SWU's produced by any process.

Uranium enrichment options. The United States is now using the gaseous diffusion technology in plants originally built in the late 1940's and early 1950's. It is also building the gas centrifuge enrichment plant, GCEP, and it is developing both the advanced gas centrifuge, AGC, and atomic vapor laser isotope separation, AVLIS. The CBO study has examined several investment options using these technologies. Here I will discuss three from the perspective of the complete system designed to deliver enriched uranium from now until the year 2025. This projection period captures the full life of each new process, as well as the costs needed to operate current gaseous diffusion plants. These options are based on data from the DOE operating plan of January 1983.

Option 1 would involve completion of an eight-building GCEP complex using only the proven GCEP technology, termed set III and set IV, and not the advanced materials, set V. Production from the GCEP plants would begin in 1988, gradually reaching a maximum annual capacity of 13.2 million SWU by 1997. One gaseous diffusion plant would be shut down, and the remaining two would provide another 13.3 million SWU per year, for a total capacity of 26.5 million SWU per year by 1997.

Because this option would not include technology still in the development stages—AGC and AVLIS—it is conservative in its underlying assumptions about the process that could be available for commercial deployment. Production from gaseous diffusion would also play a large part in the option 1 enrichment system. For these reasons, the cost estimates for this option are relatively firm.

Option 2 would represent a commitment to the AVLIS process in place of GCEP. The option assumes that three AVLIS plants would be built, producing a total of 26.5 million SWU annually. Production from the first plant would start in 1994. The existing gaseous diffusion plants would provide all the SWU requirements until then, and the GCEP project would be halted at the end of fiscal year 1983, involving a one-time-only expense for decommissioning the project. The three gaseous diffusion plants would stop commercial production in 1999.

Option 3 would represent a commitment to building AGC using set V technology. Further development of the AVLIS process would cease. As in option 1, an eight-building GCEP complex would be built. Centrifuge machines using the earlier set III technology would be installed in the first two buildings, and a somewhat improved version of the set IV machines in buildings three through six. The advanced machines—set V—would be installed in the last two buildings and, in the 1990's, they would replace the earlier machines in buildings one through six. Production from the AGC complex would reach a maximum annual capacity of 26.5 million SWU by 1999, at which time production from the gaseous diffusion plants would cease.

The results of the analysis. The purpose of the study is simply to determine the most cost-effective mix of technologies for supplying uranium enrichment. Because enrichment is a Government-owned program, CBO reports the discounted present value of the Federal outlays needed to operate each system at its assigned production level through the year 2025. The study also reports average lifetime enrichment costs in terms of discounted 1983 dollars per SWU, because the cost of production is important to the utility customer.

The analytical results, shown in table 1, point out that options 2 and 3, using AVLIS and AGC technologies, would be much less expensive than option 1, using only the proven GCEP and gaseous diffusion technologies. Table 1 appears on the chart to your left, and also appears in the charts that are printed at the end of my testimony.

The analysis also suggests that the most cost-effective option would involve development and completion of the AGC. However, the difference in costs between the two advanced technology options, AVLIS and AGC, could be rather small, perhaps $4.8 billion in present value of Government outlays over a 43-year period.

Option 3, introducing AGC in the mid-1990's, would cost the Government roughly $28 billion in outlays over the next 43 years, while option 2, introducing AVLIS in 1994, would cost slightly more—$32.8 billion.

Mrs. LLOYD. Excuse me, Dr. Bodde, for those that can't see the board, this is on page 13——

Mr. BODDE. Yes.

Mrs. LLOYD [continuing]. Of your prepared statement.
Mr. BODDE. Yes.
Mrs. LLOYD. Thank you.
Please proceed.

Mr. BODDE. This $4.8 billion difference between the two less costly alternatives, options 2 and 3, amounts to only $115 million per year over the span of the analysis. In contrast, option 1, which employs the proven GCEP technology, would cost roughly $41.4 billion in present value Federal outlays—roughly $13.4 billion more than the AGC option.

For comparison, the CBO study also examines a situation in which the existing gaseous diffusion plants supply all enrichment needs through the year 2025, reflecting the abandonment of the new technologies. The outlays needed to support this program at the same production levels as the three options would be roughly $58 billion, more than twice the cost of the least expensive AGC option. It should be noted, however, that from now through 1990 operation of the existing gaseous diffusion plants would cost roughly $15 billion in outlays, while the AGC option would require about 18 billion, and the AVLIS option about 15 billion. The AVLIS option would have short-term costs similar to the gaseous diffusion plants because large-scale construction would not begin until 1990.

Assumptions. In the assumptions—shown in table 2, which appears on the screen, and again on the charts at the end of my testimony, on page 14 of the testimony—in the assumptions used to derive these results, all the cost estimates are based on current DOE data. The options all presume a conscious attempt to retain the current U.S. share of world markets. Hence, they are designed to supply 26.5 million SWU per year with all new technologies operating at full capacity. This is the production level used in DOE's recent medium-range demand forecast in the operating plan of January 1983.

The financial assumptions are a 4-percent real discount rate applied to all future cost streams to bring these costs back to their present values, and a 4-percent real interest rate applied to all capital costs, amortized over 25 years. Finally, power costs are assumed to rise at a real rate of half a percent per year.

Included in the enrichment production charges are interest, depreciation, closing the gaseous diffusion plants as necessary, and penalties associated with using less power than is called for under the current electricity contracts. Thus, these charges are set at levels that allow full cost recovery for each option, measured over the system's entire lifetime through 2025. These costs probably will not represent DOE's actual SWU prices, since DOE sets average prices over 10-year periods, and the CBO study uses lifetime costs. But they will be close.

Because the analysis concerns some unproven systems, it is important to test the sensitivity of the results against alternative financial, cost, production, and demand assumptions. These changes in assumptions, together with the results, are summarized in table 3. Again, this appears on the screen to your left and in the chart at the end of my testimony.

Lifetime SWU enrichment charges are used as a basis of comparison, because they tend to be most sensitive to changed assump-

tions. In cases where identical changes are made in assumptions regarding project introduction schedules, power costs, and discount rates, the absolute cost of each option also changes, but the rankings do not. Option 1, using gaseous diffusion and GCEP, remains the most expensive, while option 3, the AGC option, remains the cheapest.

For example, when capital cost overruns are assigned to all the new technologies, the rankings hold. But if the capital costs for AGC, option 3, are raised to the level shown in the cost overrun line of table 3, while the estimates for AVLIS are not, then the production costs per SWU for the AVLIS option would be only $31, compared to $33 under the AGC program. Any assessment of the likelihood of such overruns, however, is beyond the scope of this analysis.

In another test, the United States is assumed to build each option to meet current production forecasts of 26.5 million SWU per year, but actually produces only 19.6 million SWU per year. This scenario might represent loss of a significant share of foreign markets in the late 1990's, thus eliminating the demand for production at full capacity. Again, the ranking of the results does not change. The AGC option remains the most economic, and the GCEP plan is the least so. However, the estimated production cost per SWU of the AGC option would rise by 20 percent, from about $27 to about $32.

The rankings of the options also hold when planned U.S. enrichment capacity is scaled back to meet the primary domestic demand—19.6 million SWU per year after the year 2000, as opposed to 26.5 million under base-case assumptions. In this situation, the most economic approach remains the AGC option, with a discounted production cost of about $32 per SWU. Option 1, using current GCEP technology, is the most expensive, with SWU costs of about $39, and option 3 falls in between at roughly $34 per SWU.

In conclusion, Madam Chairman, the results of CBO's analysis suggest that, although the relative cost differences among the options are indeed small, building the AGC process in full would result in the lowest costs to the government and to the consumer. The results also show that, if the AGC process did not perform as expected, the next best alternative would be to build AVLIS. The least cost-effective choice would be to build the GCEP complex at the current stage of proven technology, although even this option would prove substantially less costly in the long run than continuing to operate the existing diffusion plants.

In all cases, however, these results must be considered in the light of two inherent uncertainties. First, technological factors beyond the scope of this analysis could significantly affect costs. Because the differences among the leading options are small when measured against the total enterprise cost over the life of the enrichment plants, such changes could reverse the rankings presented here. Second, excess world enrichment capacity, the large inventory of existing SWU's, and foreign producers concerned with maintaining market share could lead to serious price-cutting over the period of the analysis. Such an environment might not support full cost recovery by any technology built here or abroad.

Madam Chairman, that concludes our prepared statement. We would be pleased to respond to your questions.

[The prepared statement of Mr. Bodde follows:]

STATEMENT OF DAVID L. BODDE
ASSISTANT DIRECTOR
FOR NATURAL RESOURCES AND COMMERCE
CONGRESSIONAL BUDGET OFFICE

Before the
Committee on Science and Technology
Subcommittee on Energy Research and Production
United States House of Representatives

July 28, 1983

Madam Chairman, I am pleased to appear before your Committee to discuss federal investment options for supplying enriched uranium. The issue before the Congress is whether to continue using the existing enrichment technology or to finance new processes and if the latter, which new technology might prove to be the more cost-effective investment.

My remarks this morning will touch on three points:

- The status of U.S. enrichment services in the context of the world market;
- Options to lower the costs of the United States' enrichment services and the economic consequences of these options; and
- The major uncertainties that surround the analysis.

My remarks are drawn from material in a detailed study CBO is now preparing for your Committee.

The CBO's economic analysis indicates that advanced new processes could significantly lower both the cost of providing enrichment services and the price that customers pay for nuclear fuel. Of the candidate technologies that CBO has examined, the Advanced Gas Centrifuge process, termed AGC, appears to be the least expensive from the viewpoints of both the government and the utility consumer. But compared to the total cost of the enrichment enterprise over a 43-year operating period--the span of CBO's analysis--the differences among the leading technologies appear small.

These findings must be viewed in light of two uncertainties, however. First, technical difficulties can arise in development of any new process, and the effects of these difficulties, cannot be anticipated in economic analysis. Second, the world market for this product has become highly competitive since the United States began to sell enriched uranium more than a decade ago, at times influenced by factors quite separate from price. Thus, the United States' ability to supply enrichment at low cost cannot guarantee that a customer will be found for the product.

U.S. URANIUM ENRICHMENT SERVICES IN A WORLD MARKET

Electric utilities needing enriched uranium to fuel nuclear reactors provide the Department of Energy (DOE) with uranium feed and receive the enriched product in return. The amount of work required to enrich natural uranium sufficiently for use as reactor fuel is defined as the Separative Work Unit, or SWU. A reactor requires roughly 80,000 to 120,000 SWUs a year under the typical U.S. enrichment specifications. By law, the U.S. enrichment enterprise must recover its full investment and operating costs. This leads to a charge of about $140 per SWU, roughly 4 percent of the average delivered cost of nuclear-generated electricity. Enriched uranium fuels roughly 144 gigawatts (or 144 million kilowatts) of installed nuclear capacity in the free world, of which about two-fifths is in the United States and three-fifths is overseas.

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The U.S. position as an international supplier of enriched uranium has diminished markedly. Between 1969 and 1979, the United States was the dominant free-world supplier of enrichment services, but it now supplies less than 35 percent of the market outside the United States. Three related factors that have influenced this drop are price, overcapacity, and a desire for energy independence by foreign producers.

Price. Some foreign producers charge as little as $100 per SWU--$40 less than the U.S. rate. To some extent, the strength of the U.S. dollar against foreign currencies and other nations' public support for their enrichment plants account for this disparity. This price difference has motivated concern that the United States invest in technologically advanced facilities capable of producing SWUs at significantly lower costs.

Overcapacity. Global overcapacity in SWU production is a second reality influencing the world market. A large global SWU inventory is building--estimated at roughly 60 million SWUs, or a three-year world supply at the current rate of consumption. World enrichment capacity today is about 42 million SWUs and may expand. Of this, foreign enrichment plants can supply almost 15 million SWUs a year, including Soviet exports of roughly 3 million SWUs a year. The United States is now capable of supplying about 27.3 million SWUs a year. Net U.S. capacity is not expected to increase through the end of the century, but by the late 1990s,

annual foreign capacity may rise by about 6 million SWUs, leading to a global total capacity of about 48 million SWUs by that year.

Because actual growth in nuclear generation has fallen far short of earlier expectations, world demand is unlikely to exhaust this production capacity before the end of the century. Actual yearly world demand for enrichment is about 20 million SWUs. Annual production, however, is probably around 25 million SWUs, because contract provisions require many customers to take SWUs for which they have no current need. World demand is not likely to press even current capacity limits until late in the century, reaching roughly 51 million SWUs a year by the year 2000. Thus, the large inventory of enriched uranium is likely to remain a major market force, depressing world prices and fostering strong competition for sales.

Non-price considerations. Many nations entered the enrichment market to gain greater control over their energy supplies and to promote domestic industries. Already committed to the large fixed costs inherent in uranium enrichment, foreign producers may be reluctant to lose sales even to lower-priced U.S. enrichment.

Taken together, excess production capacity, a large inventory of already-enriched uranium, and the national interests of foreign suppliers introduce considerable uncertainty into the outcome of any investment

program. Foreign producers might themselves invest in low-cost enrichment technology, or alternatively, simply cut their price to the level necessary to maintain market share. Thus, a clear potential exists for a decline in SWU price, perhaps even to levels that would not support full cost recovery of SWUs produced by any process, existing or new.

URANIUM ENRICHMENT OPTIONS

The United States is now using the gaseous diffusion technology in plants originally built in the late 1940s and early 1950s. It is also building the gas centrifuge enrichment plant (GCEP), and it is developing both the advanced gas centrifuge (AGC) and atomic vapor laser isotope separation (AVLIS). The CBO study has examined several investment options using these technologies. Here I will discuss three from the perspective of a complete system designed to deliver enriched uranium from now until 2025. This projection period captures the full life of each new process, as well as the costs needed to operate current gaseous diffusion plants.

Option 1 would involve completion of an eight-building GCEP complex using only the proven GCEP technology (Set III and Set IV) and not the advanced materials (Set V). Production from the GCEP plants would begin in 1988, gradually reaching a maximum annual capacity of 13.2 million SWUs

by 1997. One gaseous diffusion plant would be shut down, and the remaining two would provide another 13.3 million SWUs a year, for a total capacity of 26.5 million SWUs per year by 1997. Because this option would not include technologies still in the development stages--advanced AGC and AVLIS--it is conservative in its underlying assumptions about the processes that could be available for commercial deployment. Production from gaseous diffusion would also play a large part in the Option 1 enrichment system. For these reasons, the cost estimates for this option are relatively firm.

Option 2 would represent a commitment to the AVLIS process in place of GCEP. The option assumes that three AVLIS plants would be built, producing a total of 26.5 million SWUs annually. Production from the first plant would start in 1994. The existing gaseous diffusion plants would provide all SWU requirements until then, and the GCEP project would be halted at the end of fiscal year 1983, involving a one-time-only expense for decommissioning the project. The three gaseous diffusion plants would stop commercial production in 1999.

Option 3 would represent a commitment to building AGC, using Set V technology. Further development of the AVLIS process would cease. As in Option 1, an eight-building GCEP complex would be built. Centrifuge machines using the earlier Set III technology would be installed in the first two buildings, and a somewhat improved version of the Set IV machines in

buildings three through six. The advanced machines (Set V) would be installed in the last two buildings, and in the 1990s, they would replace the earlier machines in buildings one through six. Production from the AGC complex would reach a maximum annual capacity of 26.5 million SWUs by 1999, at which time production from the gaseous diffusion plants would end.

Results of the Analysis

The purpose of the study is simply to determine the most cost-effective mix of technologies for supplying uranium enrichment. Because enrichment is a government-operated program, CBO reports the discounted present value of the federal outlays needed to operate each system at its assigned production level through 2025. The study also reports average lifetime enrichment costs in terms of discounted 1983 dollars per SWU, because the cost of production is important to the utility customer.

The analytical results, shown in Table 1, point out that Options 2 and 3, using the AVLIS and AGC technologies, would be much less expensive than Option 1, using only the proven GCEP and gaseous diffusion technologies. The analysis also suggests that the most cost-effective option would involve development and completion of the AGC. However, the difference in costs between the two advanced technology options, AVLIS and GCEP,

could be rather small--$4.8 billion in the present value of government outlays over a 43-year period. Option 3, introducing AGC in the mid-1990s, would cost the government roughly $28 billion in outlays over the next 43 years, while Option 2, introducing AVLIS in 1994, would cost slightly more--$32.8 billion. This $4.8 billion difference between the two less costly alternatives, Options 2 and 3, amounts to only $115 million a year over the span of the analysis. In contrast, Option 1, which employs the proven GCEP technology, would cost roughly $41.4 billion in present value federal outlays--$13.4 billion more than the AGC option.

For comparison, the CBO study also examines a situation in which the existing gaseous diffusion plants supply all enrichment needs through the year 2025, reflecting eventual abandonment of new technology development. The outlays needed to support this program at the same production levels as the three options would be roughly $58 billion, more than twice the cost of the least-expensive (AGC) option. It should be noted, however, that from now through 1990, operation of the existing gaseous diffusion plants would cost roughly $15 billion in outlays, while the AGC option would require about $18 billion, and the AVLIS option, about $15 billion. The AVLIS option would have short-term costs similar to gaseous diffusion because large-scale construction would not begin until 1990.

Assumptions

In the assumptions (shown in Table 2) used to derive these results, all cost estimates are based on current DOE data. The options all presume a conscious attempt to retain the current U.S. share of world markets. Hence they are designed to supply 26.5 million SWUs a year with all new technologies operating at full capacity. (This is the production level used in DOE's recent medium-range demand forecast in the operating plan of January 1983.) The financial assumptions are a 4 percent real discount rate applied to all future cost streams to bring these costs back to their present values, and a 4 percent real interest rate is applied to all capital costs, amortized over 25 years. Finally, power costs are assumed to rise at a real rate of 0.5 percent a year.

Included in the enrichment production charges are interest, depreciation, closing the gaseous diffusion plants as necessary, and penalties associated with using less power than called for under current electricity contracts. Thus, these charges are set at levels that allow full cost recovery for each option, measured over the system's lifetime through 2025. (These costs probably will not represent DOE's actual SWU prices, since DOE sets average prices over 10-year periods, and the CBO study uses lifetime costs.)

Effect of Changes in the Basic Assumptions

Because the analysis concerns some unproven systems, it is important to test the sensitivity of the results against alternative financial, cost, production, and demand assumptions. These changes in assumptions, together with the results, are summarized in Table 3. Lifetime SWU enrichment charges are used as the basis of comparison, because they tend to be most sensitive to changed assumptions. In cases where identical changes are made in assumptions regarding project introduction schedules, power costs, and discount rates, the absolute cost of each option also changes, but the rankings do not: Option 1, using gaseous diffusion and GCEP, remains the most expensive, while Option 3, the AGC option, remains the cheapest.

For example, when capital cost overruns are assigned to all the new technologies, the rankings hold. But, if the capital costs for AGC (Option 3) are raised to the level shown in the third line of Table 3, while the estimates for AVLIS (Option 2) are not, then the production costs per SWU for the AVLIS option would be only $31.1, compared to $33.3 under the AGC program. Any assessment of the likelihood of such overruns, however, is beyond the scope of this analysis.

In another test, the United States is assumed to build each option to meet current production forecasts of 26.5 million SWUs a year, but actually

produces only 19.6 million SWUs a year. This scenario might represent loss of a significant share of foreign markets in the late 1990s, thus eliminating the demand for production at full capacity. Again, the ranking of the results does not change: the AGC option remains the most economic, and the GCEP plan is the least so. However, the estimated production cost per SWU of the AGC option would rise by 20 percent from $26.70 to $32.10.

The rankings of the options also hold when planned U.S. enrichment capacity is scaled back to meet primarily domestic demand--19.6 million SWUs a year after the year 2000, as opposed to 26.5 million under the base case assumptions. In this situation, the most economic approach remains the AGC option, with a discounted production cost of $31.8 per SWU. Option 1, using current GCEP technology, is the most expensive, with SWU costs of $38.60, and Option 2 falls in between at roughly $34.40 per SWU.

CONCLUSIONS

The results of CBO's analysis suggest that, although the relative cost differences among the options are small, building the AGC process in full would result in the lowest costs to the government and to the consumer. The results also show that, if the AGC process did not perform as expected, the next best alternative would be to build AVLIS. The least cost-effective

choice would be to build the GCEP complex at the current stage of proven technology, although even this option would prove substantially less costly in the long run than continuing to operate the existing diffusion plants.

In all cases, the results must be considered in light of two inherent uncertainties. First, technological factors beyond the scope of this analysis could significantly affect costs. Because the differences among the leading options are small when measured against total enterprise cost over the life of the enrichment plants, such changes could reverse the rankings presented here. Second, excess world enrichment capacity, the large existing inventory of SWUs, and foreign producers concerned with maintaining market share could lead to serious price-cutting over the period of the analysis. Such an environment might not support full cost recovery by any technology built here or abroad.

TABLE 1. RESULTS OF THE CBO ANALYSIS

	Option 1 GCEP	Option 2 AVLIS	Option 3 AGC
Technology Schedule	Production begins in 1988	Production begins in 1994	Production begins in mid-1990s
	Eight-building GCEP complex reaches full capacity in 1997	Reaches full production in 1998	Eight-building complex reaches full capacity in 1999
	Gaseous diffusion fulfills remaining capacity requirements through 2025	Gaseous diffusion capacity retired	Gaseous diffusion capacity retired
	(In billions of 1983 dollars)		
Total Discounted Federal Outlays, 1983-2025	41.4	32.8	28.0
	(Cost per SWU in 1983 dollars)		
Average Discounted Enrichment Cost, 1983-2025	39.4	31.1	26.7

SOURCE: Congressional Budget Office.

TABLE 2. BASE ASSUMPTIONS IN THE CBO ANALYSIS

- Current Department of Energy estimates on technology costs and schedules form the basis of the analysis.
- Enrichment options are designed to supply roughly 26.5 million SWUs a year in the next century, fulfilling all domestic and a significant portion of foreign demand.
- A 4 percent real discount rate is used.
- For computing SWU prices, a 4 percent real interest rate amortized over 25 years is imputed on all capital costs.
- The analytical horizon used extends from the present to 2025 to capture the full economic life of each system.
- Power costs are assumed to rise at a real annual rate of 0.5 percent from the current contract level.

SOURCE: Congressional Budget Office.

TABLE 3. ENRICHMENT PRODUCTION COSTS UNDER ALTERNATIVE ASSUMPTIONS (Costs per SWU in 1983 dollars)

Assumptions	Option 1 GCEP	Option 2 AVLIS	Option 3 AGC
Base Case	39.4	31.1	26.7
Three-Year Project Delay. Production from AVLIS and AGC begins three years later than planned.	NA	34.7	29.1
Project Cost Overruns. Equipment costs increase by 100 percent for AVLIS and AGC; building costs for GCEP and AGC increase by lesser amounts.	40.0	38.0	33.1
Higher Discount Rate. A 6 percent discount is used instead of the 4 percent of the base case.	30.6	25.7	22.6
Higher Power Costs. Real power costs rise by 2 percent rather than 0.5 percent.	45.6	32.8	27.7
Low Capacity Utilization. Capacity to produce 26.5 million SWUs is built, but only 19.6 million SWUs a year are produced.	40.3	36.0	32.1
Smaller Capacity System. Capacity to produce only 19.6 million SWUs a year is built and used.	38.6	34.4	31.8

SOURCE: Congressional Budget Office.

Mrs. LLOYD. Thank you very much, Dr. Bodde. We appreciate your fine statement and the good work that you have done on the uranium enrichment program.

We are happy that Mr. Walker is with us now and that Mr. Ottinger is with us.

We put your opening statement in the record. If you have any opening comments, the Chair would welcome them.

Mr. WALKER. No, Madam Chairman. I would like to read my statement. I think, under the new rules, that probably we are going to have to actually go through the statements rather than include them in the record. And since I do have some things here, I would, if I could——

Mrs. LLOYD. Without objection, please proceed.

Mr. WALKER. [continuing]. Like to include my statement in the record at this point.

Madam Chairman, I welcome the opportunity to discuss the report by the Congressional Budget Office on "Supplying Enriched Uranium Through the Year 2025." While I realize that our discussion today will be limited to the CBO report, I believe that the overall topic of the proper government role in the future in uranium enrichment activities is one which this committee must address in the near future.

In earlier hearings on the Department of Energy 1984 budget request, we examined the funding for the new gas centrifuge enrichment plant already under construction at Portsmouth, Ohio. However, we are interested in the possibility that the Portsmouth facility may be a proper candidate for advanced gas centrifuges which should be developed by the end of this decade. We are also quite interested in the atomic vapor laser isotope separation, the AVLIS process. These options are all included in the CBO report and will be discussed here today.

I am concerned, however, that this report does not address our world and domestic uranium markets and how does the DOE pricing policy relate to actual costs and our ability to compete in the marketplace.

We will also have to look with some care at the effects of the uranium secondary market and how it will impact on the various strategies which DOE might adopt to reclaim American leadership in the world market.

All of these options will have to be examined in considerable detail before we will be able to recommend a course for this Nation in the future.

I'd like to welcome our witnesses before our committee this morning. I thank Dr. Bodde for his statement, and look forward to the questioning that will follow.

Thank you, Madam Chairman.

Mrs. LLOYD. Thank you very much.

Dr. Bodde, looking at—first of all, you know that GAO did find some technical problems with DOE's economic model. I think you are aware of this.

Mr. BODDE. Yes.

Mrs. LLOYD. Did you use your economic computer model or did you use DOE's?

Mr. BODDE. No. We used a model of our own. We used DOE assumptions and input data, but we developed our own model.

Mrs. LLOYD. Would you expand on this a little?

Mr. BODDE. Yes.

John, would you like to discuss the model and the way we put that together?

Mr. THOMASIAN. The DOE model is fairly complex and it is difficult to determine what went into it. So we decided to use a simplified approach. We essentially put together accounting models, and used assumptions—cost assumptions on the technologies and financial assumptions—of our own.

Our first approach was simply to see how well they correlated with past DOE work. We saw that they did in a fairly proper sequence, proper way. And we felt that our model, which was simpler, was good to use, and we went ahead with it.

But essentially our model is straightforward. It uses accounting models. They extend the costs of each technology over the life of the analysis and bring them all back to present costs, and add things together and give you your outcome.

Mrs. LLOYD. Another question relating to GAO. They stated that DOE's 1980 uranium enrichment strategy study shows that the economics of building GCEP is really dependent upon the demand for enrichment. It says that GCEP is not economical at demand levels of 250 gigawatts in the year 2000.

What does your study show? Do you agree with the GAO assessment?

Mr. THOMASIAN. That is a good question. We looked at it backing down to 75-percent capacity. That's something under, oh, about 370 gigawatts or something. So we really haven't analyzed something at 250 gigawatts.

Off the top of my head, I would say that would still allow you to have SWU prices below the current world price in our analysis—it's roughly under $100. But I can get back to you and give you more exact data on that.

Mrs. LLOYD. If you would supply this for the record, we'd certainly appreciate it.

[The information follows:]

[Please refer to CBO report, Uranium Enrichment: Investment Options for the Long Term, which is included in the record.]

Mrs. LLOYD. Turning to your analysis, option 3 assumes that all gaseous diffusion plants are going to phase out before the year 2000. It assumes it will phase in the AGC machines as soon as they can be manufactured in quantity; is that correct?

Mr. BODDE. Yes.

Mrs. LLOYD. What years does it assume that they will be available in option 3?

Mr. BODDE. We have in option 3 the GDP plants phase out by 1999. The AGC plants are phased into the GCEP project in 1994, and will be running at maximum capacity by 1999.

Mrs. LLOYD. OK.

If we were to suggest to modify option 2 to keep an R&D program on AVLIS, do you feel this would change the relative enterprise costs of option 3 versus option 2—keep an R&D program?

Mr. BODDE. If we kept an R&D program at about the current rate for AVLIS, at about $100 million per year, we estimate that that would add about $1.1 billion in present value cost, if that were run through 1995. We don't see that as changing the relative rankings of the options presented here.

Mrs. LLOYD. This is not a relative factor then?

Mr. BODDE. No, it does not upset the relative ranking.

Mrs. LLOYD. In looking at the AVLIS development cost, is this computed assuming that savings are going to be obtained from piggybacking our investments in the SIS technology? And we know that there is some base work, R&D work, that does also apply to the AVLIS.

Mr. BODDE. We would have to check on the extent to which such piggybacking has indeed occurred. Our impression is that the effect is rather small on the results of the analysis, but we would like to check that and get back to you.

Mrs. LLOYD. Of course, $5 billion is $5 billion. That is a lot of money. But, really, does the cost difference between option 2 and 3, are they significant when you take into account the uncertainties in the calculations of, say, the enterprise costs?

Mr. BODDE. No, they aren't, when you consider the technological uncertainties and the fact that the span of the analysis goes over 43 years.

Mrs. LLOYD. Forty-three-year time period and——

Mr. BODDE. Yes.

Mrs. LLOYD [continuing]. There are variations in——

Mr. BODDE. That's right. It is a relatively small difference.

Mrs. LLOYD. Of course, you have chosen to address the appropriate weight that could be given in the technological risks—that is, the risks that perhaps the technology will not work, it will take longer, and the development process.

If we were to select an option which would basically minimize our risks, we might choose option 3, and then have a continued R&D program on the AVLIS technology. What do you think about that?

Mr. BODDE. Again, that would not upset the rankings of the three options that we have examined here. We estimate that a research program for AVLIS would add about a present value of $1.1 billion over the timespan of the analysis, which would not change the rankings presented here. The AGC option, option 3, would still prevail.

Mrs. LLOYD. Mr. Ottinger.

Mr. OTTINGER. Thank you, Madam Chairman.

I'm concerned with a number of things. I might also like to congratulate you on a thorough and interesting study.

I—at the end of your testimony—if I can find it—you indicate two reservations, the second of which is—you want me to use this thing? You indicate two res—is this on? I'll speak loud. The second of which says, the "excess world enrichment capacity, the large existing inventory of SWU's, and foreign producers concerned with maintaining market share could lead to serious price cutting over the period of the analysis. Such an environment might not support full cost recovery by any technology built here or abroad."

And isn't that what's actually happening at the present time with the enrichment capacity, and where does that lead us?

Mr. BODDE. Well, there certainly seems to be a short-term problem building. I think all of that has to be put in the category of a very uncertain situation, however. It is not clear what the behavior of foreign producers will be, nor is it clear what the behavior of those who now hold these inventories of enriched uranium will be.

There are clear incentives, however, for price cutting, both in the near term and in the long term. These are the classical incentives that apply to a high-fixed-cost business to cut price down to operating costs.

Mr. OTTINGER. What share of the foreign market do you assume through the year 2025 in your study?

Mr. BODDE. We've assumed that, for the base case, DOE produces at about the current level, 26.5 million SWU per year, which would continue about its current market share.

Mr. OTTINGER. Did you do any independent evaluation, or is there any independent evaluation of that assumption?

Mr. BODDE. No. We have simply taken that from the DOE case. That is a very difficult sort of thing to evaluate.

Mr. OTTINGER. I agree, but isn't it essential that that——

Mr. BODDE. We've tested the sensitivity of that, of course, by assuming two things. One, that we plan a production level of 19.6 million SWU; and second, that we plan for the higher level, but actually get a production level of 19.6.

Mr. OTTINGER. The results are the same?

Mr. BODDE. Yes. And the rankings came out as you see in table 3.

Mr. OTTINGER. Are the figures still accurate in the—I guess it's the DOE study? I am not sure whether it comes from DOE or Union Carbide and the Laurence Livermore Laboratory. But the estimates that I have as of last year that, under GCEP, a SWU would cost $70 to $80. The thing was completed and, "production under AVLIS's SWU would cost $20 to $20."

Mr. BODDE. Mollie, do you want to comment on that?

Mr. OTTINGER. Current technology?

Ms. QUASEBARTH. All the data that we used came out of the DOE's January operating plan. DOE is currently revising numbers for both AGC and AVLIS, and the cost numbers are getting revised, as well as the introduction schedules. And they're not official yet. As soon as they are ready to turn them over, we're going to look at them and examine them and see if they change our results any.

Mr. OTTINGER. What are your figures for set V versus AVLIS cost per SWU?

Mr. BODDE. John, do you have those?

Mr. THOMASIAN. I think we have set V—well, this is discounted, so that brings up a little bit of a problem. Let me bring them back to undiscounted.

I think we're running set V at about $22 to $25 per SWU. AVLIS is a little higher than that. I'd say—I think near $30. But those are—I have to think in my head and bring them back from undiscounted to—discounted to undiscounted and get back to you.

Mr. BODDE. We would like to get back to you in writing on that question, sir.

Mr. THOMASIAN. There's two things to separate, if I can add. There's one at program cost, which also includes some of the early gaseous diffusion use in simple head-to-head competition between the technologies. The trends follow roughly these, which are AGC, a little lower than AVLIS. But I can give you the more exact figures.

Mr. OTTINGER. Is it better to say the cost effectiveness of the set V depends on relatively full utilization of the facility because of the high production costs?

Mr. THOMASIAN. There's some sensitivity there, certainly, and we try to get a sense of that in our 75 percent versus 100 percent capacity run. At what level does AGC no longer prevail in its small way over AVLIS? I don't know yet. And we can look into that.

But, yes, there's sensitivity, certainly. There's a lot of fixed costs that have to be spread over a lot of SWU's.

Mr. OTTINGER. We're at—we're at a situation now where we're paying all kinds of capacity costs for power on the diffusion machines because they aren't being used to capacity. And one would like to avoid that. It seems to me one of the advantages of AVLIS, if it works, is that there are smaller modules, and it is less likely that you'd have to overbuild. Is that a significant consideration?

Mr. BODDE. Yes, sir. Anytime in a high-fixed-cost business that you can follow demand, it's more economic than if you can't follow demand.

Mr. OTTINGER. Would it be worthwhile to have you pursue the best analysis that you can do on the likelihood of what's going to happen to our ability to compete in foreign markets over the period that we are considering?

Mr. BODDE. Yes, sir. We could look at that question. Although I think it is largely going to be indeterminate, because it's based invariably on assumptions about what independent foreign producers do and independent foreign holders of enriched materials do.

Mr. OTTINGER. I assume that you've got to make these plans based on the most realistic assumptions that we can garner. I—we're faced with the GAO report from just last year that said, I quote,

> The centrifuge plant is not justified at current expected demand levels. The construction of the plant would be economical if events caused a sudden increase in demand for nuclear power or if DOE's efforts that does involve AIS technology failed. If either of the events occur, however, DOE has sufficient time to build new capacity.

I take it that in your——

Mrs. LLOYD. Would the gentleman yield?

Mr. OTTINGER. Yeah.

Mrs. LLOYD. I think this certainly ignores the advantages of moving ahead with our set V machines.

Mr. OTTINGER. As you know, I advocate moving ahead with set V machines.

Mr. DUGAN. The DOE report doesn't. It assumes you got——

Mr. OTTINGER. Yeah.

Did you look into at all the economic consequences of trying to leapfrog the set III and set IV holdup on the actual installation of those machines, hold the thing up for the set V machines instead?

Mr. BODDE. John.

Mr. THOMASIAN. I'm familiar with your proposal in that area. We didn't look at it per se. We understand GAO has, but I'm not aware of the results.

Our programs assume a continuance of all projects, meaning that there is no interruption in the production schedule if one is approaching production, i.e., GCEP. So, in that sense, no, we haven't looked at that. I would assume there might be some penalties involved in interrupting it. Whether that would change our rankings isn't clear. That would be something we'd be interested in looking at.

Mr. OTTINGER. Is that something you could look at reasonably?

Mr. THOMASIAN. Yes, sir, we could. We would need some technical help in that, but I think we could.

Mr. OTTINGER. Thank you, Madam Chairman.

Mrs. LLOYD. Thank you very much, Mr. Ottinger.

Didn't you base your assumptions on putting the set V machines in at an earlier date than the DOE assumptions?

Mr. BODDE. No; we based ours on the DOE January 1983 plan.

Mr. OTTINGER. If the gentlelady would yield.

Mrs. LLOYD. I yield.

Mr. OTTINGER. I didn't quite understand. The question was raised earlier. Did you assume that the AVLIS would be piggybacked on the defense program?

Mr. BODDE. We made no assumptions in that regard, sir. We would have to look at what costs of the laser isotope separation program had indeed been borne by defense. I suspect that's going to be a very difficult thing to unbundle ultimately.

Mr. OTTINGER. It could have a substantial effect on the AVLIS cost, couldn't it?

Mr. BODDE. Given the DOE pricing formula, if there really was a large set of costs in the past that should properly be charged to a certain technology, certainly, that has to be reflected in the price that the DOE charges for its SWU. So, yes, if that is a large number, then it could have such an effect.

Mrs. LLOYD. Mr. Walker.

Mr. WALKER. Thank you, Madam Chairman.

You state that foreign producers charge as little as $100 per SWU. We've been told that the secondary market supply's enriched uranium at somewhat higher prices. What is the extent in each case?

Mr. BODDE. It's hard to say how deep that market is at this point. John, do you have the sense of that?

Mr. THOMASIAN. From what we can garner, it looks like 75 percent of the world inventory at any time is available for sale. It appears that one of the strategies that's occurring—I can't say I have firm data on this—is that the SWU prices from the secondary market will be sold at a level that, when you add the cost penalties of breaking a contract here, plus the cost of the SWU's, will still be lower than our price, so that you find about a level of about $109 per SWU.

Mr. WALKER. Well, what percentage would be available at $100?

Mr. THOMASIAN. That, I don't know. All I know is simply that 75 percent of the world inventory is available for sale. Seventy-five percent of what is contracted may not be used.

Mr. WALKER. We're told that the price that is quoted is more like $120 to $125, that that is a more realistic kind of price. Do you have real reason to think differently than that?

Mr. THOMASIAN. No; only that I've heard the $100 range often also.

Mr. BODDE. I'm sure there's a range of prices that are charged for these things. And that in a fairly thin market, one could expect rather wide fluctuations, depending upon the timing and the needs of the buyers and sellers.

Mr. WALKER. You advise that the foreign producers might invest in low-cost enrichment technology. Do you have any indications that this is taking place?

Mr. BODDE. At present, the United States is well in the lead in developing its enrichment technologies. We have no indications that foreign producers would or would not make a serious attempt to duplicate the American technological advantage, nor do we have information about the timing of such things.

However, the span of the analysis is over 43 years and, over such a period, a large range of possibilities are indeed open.

Mr. WALKER. Among the three uranium enrichment options, which one most closely adheres to the present requirement of full cost recovery?

Mr. BODDE. We have assumed full cost recovery in all of our options. We have measured full cost recovery over the span of the—over the 43-year span of the option.

Mr. WALKER. OK. How confident are you of those conclusions?

Mr. BODDE. Whether or not full cost recovery is achieved depends, of course, upon selling at the price that one has. If those sales are not in fact achieved, then there could be cash flow problems that might, in any given year, make full cost recovery difficult.

Mr. WALKER. Let me go back to my question about the foreign producers for just a second. Does it appear that other governments are willing to subsidize to whatever level is necessary to make a sale?

Mr. BODDE. The evidence on that is very, very soft. There is certainly the classic economic incentive that applies to a high-fixed-cost business. It would apply there as well. They certainly have more flexibility in their pricing. Beyond that, it's very difficult to say what their pricing behavior would be.

Mr. WALKER. There are two significant commitments in the gaseous diffusion program. One's the capital account or the value of the plant, and the other is the electric power contract.

How are these commitments written off as you go from gaseous diffusion to centrifuge or to laser isotope?

Mr. BODDE. John, do you want to cover that one?

Mr. THOMASIAN. As far as the electric power side, if we don't use the power, and it's in the contract that there's a penalty, we add the penalty to the total enterprise cost. As the gaseous diffusion plants are decommissioned, another aspect, we add the cost of decommissioning to the enterprise costs.

So, any of the SWU processes you see up there have embedded in them costs of decommissioning the gaseous diffusion plants, using the power, or losing the power and paying the penalty. The decom-

missioning estimate is the least firm of estimates, i.e., one doesn't really know how much it costs.

Mr. WALKER. So the price is reflected in your study——

Mr. THOMASIAN. Yes.

Mr. WALKER [continuing]. And the full cost recovery analysis reflected in your study, in each case, involves the writing off whatever commitments may be in place.

Mr. THOMASIAN. That is right.

Mr. WALKER. Thank you, Madam Chairman.

Mrs. LLOYD. Thank you very much, Mr. Walker.

Dr. Brodde, I think that some of the problems we've seen—perhaps you'll agree with me—that we've seen in getting ourselves out of the world market is just a classic example of our policy coming back to haunt us. At one time, we were considered a reliable supplier and a reliable partner, and we've certainly lost our reputation in this respect. And this is reasons for some of the investment in foreign competitors on this. Would you like to agree that this is something that we're going to have to live with because it's the result of the policy that was enacted back 6 years ago that certainly had a lot of repercussions that I've certainly seen in this committee.

But I think we have to get back to the purpose of this hearing, to base your comments, your remarks and your studies to help us determine do we want to be in this business. It's going to have to be a long-term investment. Do we want to provide a uranium enrichment enterprise that will be competitive domestically and internationally? We are going to have to look at it over the long haul, and there will be some valleys as well as peaks in this process.

Mr. BODDE. Madam Chairman, that basic choice, of course, is one that is in your problems and not that of the analysts.

Mrs. LLOYD. I think I got a nod of head out of it, though.

Mr. BODDE. But you're right. That is absolutely the basic choice.

Mrs. LLOYD. I want to go back to one other question here on your option 3. When did you put the advanced machines into production?

Mr. BODDE. Mollie, do you want to answer that?

Ms. QUASEBARTH. We assumed the GCEP project starts up in 1988 using the set III machines. Buildings three through six are fitted with a somewhat advanced version of set IV machines. Then, in the mid-1990's, 1994 and 1995, the set V machines are put into the last two buildings of the eight-building project. And, then, in the later 1990's the advanced set V machines replace the earlier machines in the first six buildings.

Mrs. LLOYD. Just a minute.

OK. I was looking at the top of page 7 of your testimony.

Ms. QUASEBARTH. Essentially, the advanced machines are phased into the full GCEP plan between 1994 and 1999.

Mrs. LLOYD. If we could advance the AGC earlier, what—how would this affect this option—to move a little faster with the advanced machines?

Ms. QUASEBARTH. Most likely it would just decrease the total cost, because you are going to be phasing out some of the production from the gaseous diffusion plants earlier. The diffusion plants need to run until, I believe, 1999, until the full set V machines——

Mrs. LLOYD. But if we could move the advanced machines in earlier, would we get a cheaper SWU?

Mr. BODDE. Yes.

Mrs. LLOYD. If we could accelerate this program?

Ms. QUASEBARTH. I would imagine so.

Mrs. LLOYD. Thank you very much.

One final question. If you would comment on the cost overruns for the advanced machines, between the machines and the brick and mortar for the plant, the cost of production.

Mr. BODDE. Our assumptions for writing cost overruns are necessarily arbitrary. They're based on a study done by the Rand Corp. some years ago of pioneer process plants that suggest that cost overruns of that magnitude are about in the ballpark for new type process plants.

We simply did that in order to test the sensitivity of the results to such cost overruns, and not because we necessarily believe or don't believe that cost overruns of that type would occur.

In terms of the breakdown between the actual machines themselves, the technology components and the bricks and mortar, if one looks at the percentage of cost for the plant, the bulk of it is indeed machines and less of it is bricks and mortar. So assumptions about overruns on the brick and mortar part are less critical than assumptions about overruns on the technology part.

Mrs. LLOYD. When you consider the status—the present status—of our centrifuge technology against the improvements required for the set V machines, isn't this a little bit extreme?

Mr. BODDE. We did have a lower cost overrun for the GCEP—did we not John—than for the advanced GCEP, the advanced AVLIS?

Mr. THOMASIAN. For proven technology, we have a lower cost overrun, which piggybacks on the current contingencies already embedded in the cost estimates.

To some extent, to answer your question, sure, it is a bit extreme. But, then, again, we are looking for changes that would cause the rankings to alter. In essence, we are pushing things to see what would happen: How much would GCEP have to rise to flip with AVLIS? So, in that sense, we arbitrarily chose the high cost.

Mrs. LLOYD. Mr. Ottinger.

Mr. OTTINGER. Did you consider the option—which I understand is a realistic one—of acceleration of AVLIS, in the phasing of AVLIS, instead of them putting it all in in 1994, what that would do to your cost estimates?

Mr. THOMASIAN. We did earlier. Those runs are in the back of my mind now, and I can't think of it. We weren't convinced that the accelerated schedules were truly valid when we were progressing with our study for either of the technologies. So we sort of abandoned those early estimates.

But, again, anytime you could bring any of the advanced technologies on earlier and phase out the gaseous diffusion, you would lower the cost of the respective option as represented in the SWU price.

Mr. OTTINGER. Is that difficult for you to resurrect?

Mr. THOMASIAN. No.

Mr. BODDE. No, sir.

Mr. THOMASIAN. Close to the surface.

Mr. OTTINGER. On page 9 of your testimony, you indicate that all these assumptions are based on a 4 percent real interest rate. In view of the real world today, why was that figure shown, and does that throw your calculations off?

Mr. BODDE. That 4 percent is a real interest rate, as opposed to a nominal interest rate. If one were to put that in nominal terms, then one would add the rate of inflation to that.

For an analysis that stretches out 43 years, any assumption about interest rate is necessarily arbitrary. But 4 percent real—that is, 4 percent with inflation backed out of it—appears to be about right for the Government interest rate over a very long term. And, for that reason, we have chosen that.

Again, interest rate assumptions, like anything else, are fairly arbitrary. We tried to test the sensitivity of that. We went with a 6-percent real over this long period, which I think is probably a bit high—but again, to push things, we went with a 6 percent real as well.

Mr. OTTINGER. You did the calculations under a 6-percent interest rate?

Mr. BODDE. Yes, sir, 6-percent real interest rate.

Mr. OTTINGER. And the results came out more or less the same?

Mr. BODDE. Yes. Again, the costs were different for each technology, but the rankings remained about the same. The two advanced technology options were quite close, as before.

Mr. OTTINGER. Are the construction cost figures that I have like ballpark? It is hard to understand. My understanding is that the complete GCEP construction would be in the neighborhood of $10 billion, whereas the complete AVLIS construction costs are in the neighborhood of $2 billion. That would make it appear that differences in interest rates and capacities would have a much more marked effect than what your figures show.

Mr. BODDE. We would have to get back to you on those construction cost estimates.

Mr. OTTINGER. What about the assumption on power costs raising a half a percent a year? Is this indicative of a trend over the past 10 years, what the DOE and GAO predict is the real price costs escalation?

Mr. BODDE. The power costs over the past 10 years, of course, have been very markedly influenced by two oil disruptions. The range of one-half percent to 2 percent was a range included in the GAO study. I think they recommended the half percent. We used that, but we also tested the effect of a 2 percent real increase.

Mr. OTTINGER. Thank you.

Mrs. LLOYD. Thank you, Mr. Ottinger.

One last, rather long, question. You mentioned—of course, we referred to this large secondary market for enrichment services. Do you think that this should be a relative factor in determining our stockpile, since this is going to be a large source of supply, say, if we should have an emergency? To what extent would minimizing the size of our stockpile reduce our enrichment costs, by bringing the stockpile down?

Mr. BODDE. We have assumed in all of our cases that the stockpile is brought down to the level that DOE thinks prudent in its

January plan. That level being one-third of the following year's expected SWU sales.

Mrs. LLOYD. Do you think that's an appropriate minimum level for the stockpile?

Mr. BODDE. We haven't looked at whether that's appropriate or not. Whether it is, of course, depends upon one's expectations and plans for dealing with an energy disruption. It may well be——

Mrs. LLOYD. And based on the secondary market.

Mr. BODDE. We really don't have a view on that. We haven't really thought of that.

Mrs. LLOYD. Maybe that's something we should be looking at in our next hearing.

One final question. Would you comment on the choice of the discount rate of 4 percent?

Mr. BODDE. I think that pretty well reflects long-term real interest rates that are appropriate for a very long period, such as one reaching out to 2025. It roughly reflects the Federal Government's cost of capital for the long term, again in real terms. To see what that would look like in nominal terms—that is, what we have to pay to borrow the money right now—one would, of course, have to add the rate of inflation to that, which would put it, oh, on the order of 10 or 11 percent in nominal terms.

All of the cost estimates in this report, however, are done in real discounted dollars.

Mrs. LLOYD. Thank you very much. We appreciate your help this morning, the very fine report that you prepared.

We would like to ask you if you would answer questions—we'd like to submit in writing.

Mr. BODDE. Certainly.

[The information follows:]

CONGRESSIONAL BUDGET OFFICE
U.S. CONGRESS
WASHINGTON, D.C. 20515

Rudolph G. Penner
Director

October 11, 1983

Honorable Marilyn Lloyd
Chairman
Subcommittee on Energy
Research and Production
Committee on Science and Technology
U.S. House of Representatives
Washington, D.C. 20515

Dear Madam Chairman:

Thank you for your letter of 29 July to Dr. Rivlin with questions on our testimony of July 28. Responses to those questions are attached. We hope these, as well as our study, Uranium Enrichment: Investment Options for the Long Term, which will be published shortly, will prove useful to your Subcommittee.

If you should wish further assistance in this area, please do not hesitate to call.

Sincerely,

Rudolph G. Penner

Enclosure

Uranium Enrichment--Responses for Chairman Lloyd

Subcommittee on Energy Research and Production

October 5, 1983

1.) **Question.** What is the total capacity of the AGCEP assumed in Option 3? What is the total production capacity needed for enrichment services through the year 2025? How much of that capacity can be provided by an eight-building AGCEP? Does this mean that if we build an eight-building AGCEP, we will not need the additional capacity that the AVLIS technology can provide?

Answer. The AGC project as defined in Option 3 1/ would provide a total production capacity of 26.5 million SWUs a year by 1999, assuming a uranium tails assay of 0.25 percent. Under the analysis assuming a medium SWU demand schedule, annual demand for U.S. enrichment services is projected at 26.5 million SWUs from 2003 to 2025; thus, the eight-building AGC complex fitted with Set V advanced gas centrifuges would be capable of meeting full demand requirements over this period.

However, under an alternative production scenario that assumes an operating tails assay of 0.10 percent rather than 0.25 percent from the year 2000 to 2025, the capacity requirements would increase to 42 million SWUs a year; at the same time, though, feed requirements would be greatly reduced. Under this production schedule, it would most probably prove cost effective to operate the full 26.5 million SWU capacity AGC complex in conjunction with two AVLIS plants to produce the required 42 million SWUs a year.

2.) **Question.** When is it assumed that AVLIS will first be available for deployment in Option 2? How rapidly would the three AVLIS plants be brought on-line?

Answer. The AVLIS process is assumed to begin commercial production from the first of three plants in 1994, at a level of 0.9 million SWUs a year. The remaining two plants would come on-line in 1995 and 1996. Each plant would build up to its maximum production rate over a three-year period, producing 0.9 million SWUs in the first year of production, 6.3 million SWUs in the second, and 9.0 million SWUs in the third.

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1. The option numbers referred to in these responses correspond to those analyzed in the CBO July 1983 testimony. These option numbers do not correspond to those in the forthcoming CBO study, Uranium Enrichment: Investment Options for the Long Term.

3.) **Question.** Would you comment on the basis for estimating development costs for AGCEP at roughly $300 million more than AVLIS development?

Answer. After consultation with DOE's Office of Uranium Enrichment and Assessment, the development cost projections for AVLIS have been revised upward since CBO's testimony of July 1983. Total research and development costs (undiscounted) for the AVLIS program under Option 2 are estimated at $1.01 billion. An additional $150 million is to be provided through the defense program for the Special Isotope Separation (SIS) process. By comparison, the research and development costs (again, undiscounted) for the AGC program under Option 3 are $1.08 billion, roughly equal to the AVLIS development costs.

4.) **Question.** In Option 2, at what intervals would the three gaseous diffusion plants be shut down?

Answer. The three gaseous diffusion plants would be decommissioned over the period 1996 to 1999. The first would shut down in 1996, when AVLIS is projected to reach capacity of 16.2 million SWUs a year; the second plant would shut down in 1997, when AVLIS capacity would reach 24.3 million SWUs a year; the last would close in 1999, when the AVLIS complex would attain its maximum capacity of 26.5 million SWUs a year.

5.) **Question.** If we look at these options with the goal of minimizing appropriations in excess of revenues, isn't it true that the sunk capital costs would drive the choice toward Option 3 (AGCEP) since we have already spent a great deal of the required outlays for centrifuge capability, and only a very small amount of the outlays for Option 2 (AVLIS)?

Answer. The CBO analysis does not take into account federal revenue from the sale of its enrichment services. The revenue will be determined by the DOE SWU price, which is set according to the DOE pricing formula requiring that all enrichment program costs be fully recovered over a ten-year period. Thus, the current and near-future SWU price will include the most recent expenditures for the gas centrifuge and AVLIS technologies, regardless of what process is developed further.

In the CBO analysis, the total enterprise cost and outlay schedules include appropriations from the fiscal year 1984 forward; CBO does not include previous expenditures in its analysis, nor does it include monies spent for other advanced processes before this date. The CBO analysis found that, in terms of discounted federal outlays, the AGC option (3) would

be less expensive than the AVLIS option (2) by roughly $5 billion. If the $2.2 billion already appropriated and spent for GCEP through fiscal year 1983 were added to the AGC option (3), it still would be slightly less expensive than the AVLIS option (2). However, differences under both cases remain small. All of this, of course, is based on the current DOE cost estimates; as these change, so may these figures.

6.) **Question.** In terms of minimizing the potential costs of enrichment services, do you think it would be in DOE's benefit to allow its customers to reschedule their needs for enriched uranium and examine the possibility of an earlier shutdown of a gaseous diffusion plant than is assumed in any option?

Answer. If DOE allowed its customers to reschedule (most likely, decrease or postpone) their enrichment contracts--resulting in lower enrichment requirements from the gaseous diffusion plants in the short term--the enterprise costs and outlays would probably be reduced. However, DOE would pay a substantial demand penalty for power contracted for from electric utilities but not used. Thus, cutting back on gaseous diffusion production in the short term would include penalty payments for unused power.

In addition, allowing customers to opt out of their enrichment contract commitments would decrease federal revenue from enrichment sales--part of which is going toward the development of the advanced technologies and the GCEP construction. Thus, if the DOE pricing formula continues to require that revenues fully recover program costs over a ten-year period, reducing the number of SWUs actually sold in the short term might require one of three changes: enrichment price increases to fund new development and construction, protracted schedules for such investment, or reduced outlays for near-term investments.

Mrs. LLOYD. We ask unanimous consent that this report be included in the record.

[This report is available in subcommittee files.]

Mrs. LLOYD. I think we had a very informative and very good hearing. I want to thank all of those that are with us, that participated in our hearings this morning.

If there is no further business, the subcommittee stands adjourned.

[Whereupon, at 10:02 a.m., the subcommittee was adjourned.]

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